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GB 2141502 A

EP 0531643 A2

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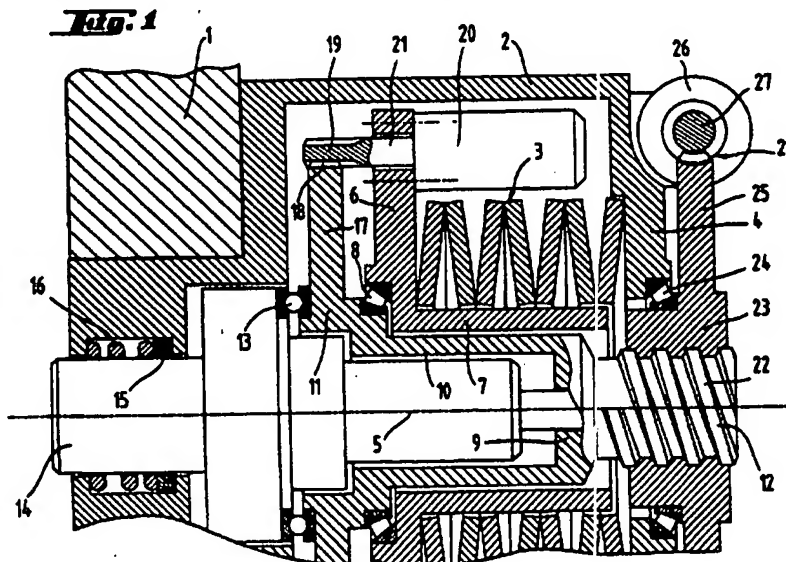
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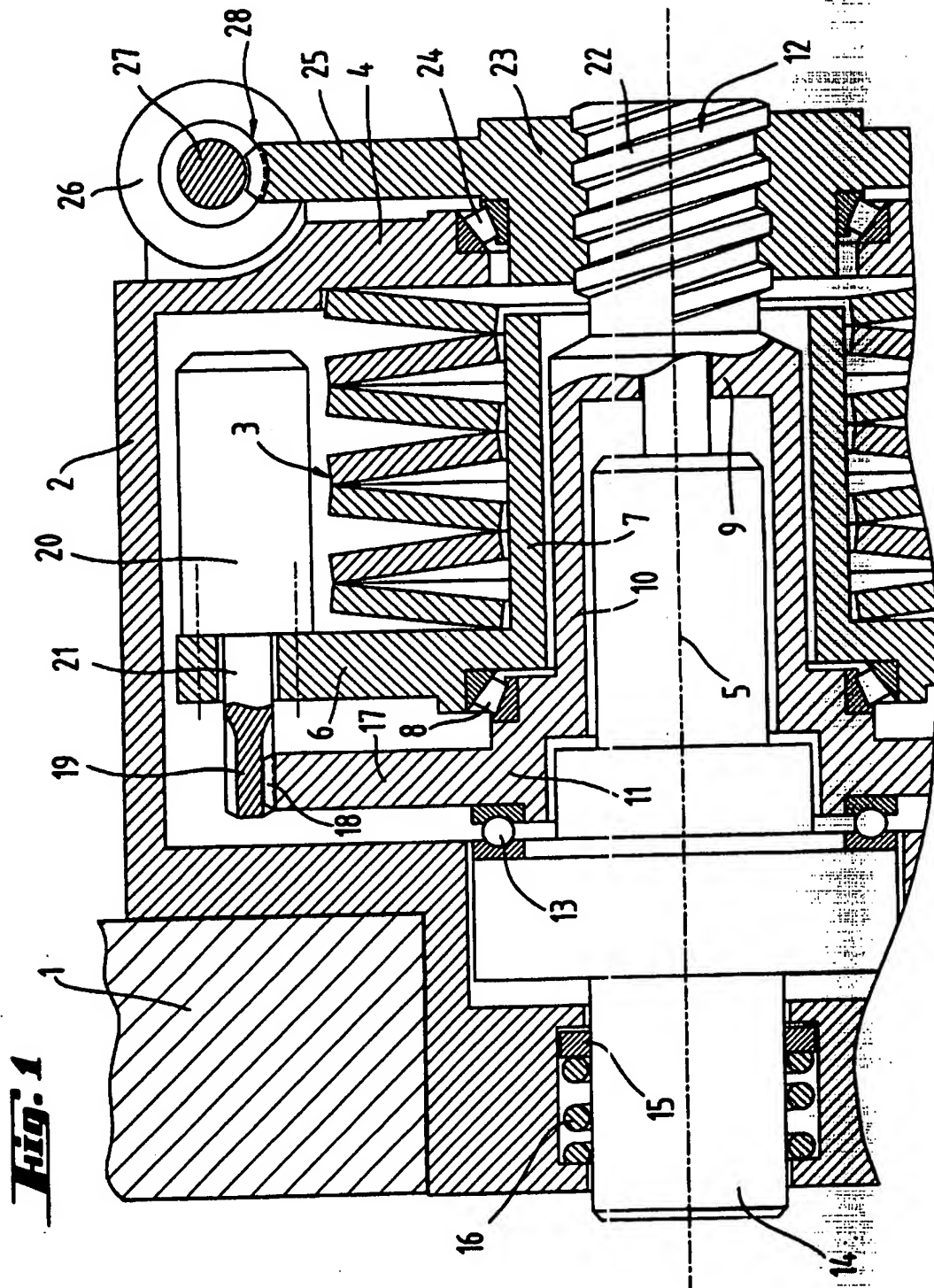
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(54) Disc brake actuation device

(57) An electromechanical disc brake actuation device has a spindle piston 9, loaded by an energy storage spring 3, coupled to a clamping piston 14 for delivering the actuating force or stroke and engaging an axially non-displaceable female part 23 by means of a non-self-locking adjusting thread 22. The spindle piston 9, under the force of the spring, can be screwed in the direction of actuation under electrical monitoring by means of a stepping motor 20, or a locking mechanism or similar, and the female part can be rotated to bring about the opposite direction of rotation of the spindle piston 9 by an electric motor 26 and a self-locking worm gearing 28. This enables the setting of relative rotations between the parts 12, 23 of the thread 22 and hence rapid and controllable braking. The clamping piston includes an integrated wear adjustment device.



GB 2312717 A





Electromechanical rail brake actuator

The invention concerns an electromechanical actuation device for the disc brakes of rail vehicles, in particular for disc brakes having a calliper or calliper frame. One construction of this kind of brake has an energy-storage spring which stores an actuating force, a clamping piston which can be axially loaded by this spring and which delivers the actuating force, a screw gearing which can be driven by an electric motor by way of a reduction gearing for loading the energy-storage spring, and a braking device which controllably monitors the rotation of a rotatable part of the screw gearing in the direction of unloading of the energy-storage spring.

An actuating device of this type is known, for example, from DE 34 23 510 C2. Known actuating devices have a complicated multipart construction, cannot be given a compact shape, do not permit the rapid changes of force required for anti-skid control devices, for example, and/or their power delivery can be controlled only poorly or inaccurately.

When a relatively hard cup-spring assembly is used as the energy-storage spring, the electromechanical actuating devices of the type mentioned above only have short useful stroke paths; this means that they are particularly advantageous for disc brakes that can be applied with short stroke paths, examples being in particular disc brakes with callipers or calliper frames, owing to their low level of elastic deformation.

From EP 0 334 434 B1, of a different generic type, it is known, in an electromagnetic actuating device, to use a pressure sensor to measure the supporting force for a part transmitting the actuating force, and thus to measure the actuating force, and to control the

brake actuation in dependence upon the measured value or to trigger other control procedures. From this publication it is also known to provide a stepping motor for controlling the actuating force and/or to
5 measure numbers of revolutions or angles of rotation of control motors using a pulse counter co-operating with teeth of a gearwheel.

DE 36 19 948 C2 shows a wear adjustment device integrated in a push rod of an otherwise completely
10 different generic type of actuating device.

An object of the invention is to construct an electromechanical actuating device, in particular of the above-mentioned type, in such a way as to enable a simple, low-cost construction with a compact design and
15 good control that is also sufficiently fast for anti-skid protection functions. Furthermore, of course, a high level of safety is to be provided, even when errors occur, by the use of the concept of the spring energy store.

20 The invention envisages an actuation device of the above-mentioned type in which, of the two parts of the screw gearing formed in a non-self-locking manner as an adjusting thread, one part is axially supported and can be driven by the electric motor in the direction of
25 loading of the energy-storage spring and the other part, which is coupled axially to the clamping piston, can be braked by the braking device, so that the two parts can be set to rotate at differential rotational speeds for controlling the actuating force that can be
30 delivered by the clamping piston.

In the subclaims there are indicated additional advantageous possible developments according to the invention for an actuating device of this type corresponding to the fundamental idea of the invention.

35 In the drawings of Figure 1 and Figure 2, two different possible advantageous embodiments of

actuation devices formed using the invention are shown as sectional views of parts thereof important for the invention, corresponding parts being provided with the same reference symbols.

5 Figure 1 shows part of a calliper or calliper frame 1 of a disc brake (otherwise not shown), which calliper or calliper frame is firmly connected (in a manner not shown), preferably detachably, to a housing 2 of the actuation device. In the housing 2 there is
10 located an energy-storage spring 3 formed as a cup-spring assembly which is supported on the one hand backwards, facing away from the calliper frame, against a wall 4 of the housing 2, and on the other hand, towards the front and in the direction of the actuating
15 force that is to be delivered, against a clamping piston 6. The housing 2, the energy-storage spring 3 and the clamping piston 6 have a common axis 5. The clamping piston 6 in half-cross-section is approximately L-shaped, having a radially inwardly
20 located tubular section 7 which supports the inner circumference of the energy-storage spring 3 and serves as its bearing.

To the front, the clamping piston 6 is supported, by way of an axial bearing 8 formed as a tapered-roller
25 bearing, against an axially displaceable spindle piston 9 which can be rotated in the housing 2; the spindle piston 9 is coaxial with the axis 5 and it too has a tubular section 10, located just inwardly of the tube section 7 of the clamping piston. This changes at the
30 front end to a flange section 11 against the energy storage-spring side of which the axial bearing 8 is supported. At the other axial end the tube section 10 changes into a threaded spindle section 12 which terminates the spindle piston 9.

35 At the other axial side of the flange section 11, facing the axial bearing 8, i.e. at about the same

radial level, a further axial bearing 13 rests against the flange section 11. A clamping piston 14 is supported against this further axial bearing 13 in the opposite direction to that of the actuating force. A
5 clamping ring 15 is seated on the clamping piston 14 and is thus fixed to it, though it can be mounted in a different way if necessary. Between this ring and the housing 2 there is mounted a spring 16 which loads the clamping piston 14 against the direction of tensioning,
10 that is to say, backwards. The forward end of the clamping piston projects from the housing 2; a brake pad (not shown), which can be displaced in relation to the calliper frame 1, is coupled to this clamping piston in a form-fitting manner in the usual way.

15 In the radially outward direction, the flange section 11 changes to a disc body 17 which is provided on its outer periphery with radial teeth 18 in which there engages a pinion 19 of a stepping motor 20 mounted in the housing 2, preferably on the clamping
20 piston 6 which cannot be rotated in relation to the energy-storage spring 3 because of friction locking. As shown, the shaft 21 of the stepping motor 20 can project through a hole in the clamping piston 6; however, as a variant of this, the clamping piston can
25 also terminate before the shaft 21 in the radial direction.

A female part or nut 23 is adjustably screwed on the threaded spindle section 12 by means of a non-self-locking adjusting thread 22, preferably formed as a
30 trapezoidal thread, so as to form a screw gearing. The female part 23 is supported against the wall 4, on the side facing away from the energy-storage spring, by means of an axial bearing 24 again formed as a tapered-roller bearing. Radially on the outside the female
35 part 23 carries a worm gear 25 which meshes with a worm 27 that can be driven by an electric motor 26; the

27 that can be driven by an electric motor 26; the electric motor 26 is preferably mounted on the housing 2. The reduction gearing 28 formed by the worm gear 25 and the worm 27 has a self-locking construction. In a manner not shown, the housing 2 can have an axial extension with which it surrounds at least the reduction gearing 28 and possibly also the electric motor 26, so that the actuation device forms a protected unit surrounded altogether by the housing.

10 In the unactuated state of the actuation device, corresponding to a released disc brake, the energy-storage spring 3 is compressed and is supported via the clamping piston 6 against the spindle piston 9 by way of the axial bearing 8; with the stepping motor 20 stationary and unexcited, the spindle piston 9 is held by way of the radial teeth 18 in a non-rotatable manner. It is also prevented from axial displacement by the adjusting thread 22, since the female part 23 is also supported in a non-rotatable manner by means of the reduction gearing 28 when the electric motor 26 is stationary and unexcited. The flux of force of the energy-storage spring 3 is thus closed by the wall 4 from the spindle piston 9 by way of the female part 23 and the axial bearing 24. The spring 16 holds the clamping piston 14 in its right-hand end position resting against the spindle piston 9 by way of the axial bearing 13.

For actuating the actuating device, that is, for clamping the disc brake, the stepping motor 20 is excited and actuated so that it rotates the spindle piston 9 in the direction of screwing to the left in the adjusting thread 22, by way of the radial gear teeth 18; at the same time, the female part 23 continues to be held in a non-rotatable manner. With a slight reduction in loading, the energy-storage spring 3 pushes the spindle piston 9 to the left with great

force, in accordance with its screwing movement in the adjusting thread 22, the clamping piston 14 being driven by way of the axial bearing 13 and actuating the disc brake and bracing it against the calliper frame 1
5 by relative displacement of the brake shoe coupled to it. During the movement to the left, the stepping motor 20 is carried along on the piston 6, so that no axial movements occur between the radial serration 18 and the pinion 19. Because of the elastic
10 deformability of the disc brake, which is always present although small, the disc brake is clamped during the left-hand stroke of the clamping piston 14 with a stroke path of increasing force, until the full force of the energy-storage spring 3 is reached; it is
15 thus possible to control the tensioning force of the disc brake by controlling the left-hand stroke path of the clamping piston 14 or of the spindle piston 9. For setting a pre-determined actuating force of the disc brake, therefore, the stepping motor 20 is actuated in
20 such a way that it rotates the spindle piston 9 through an angle of rotation (possibly several revolutions) corresponding to this force, and screws it to the left. During this, the disc brake is clamped by a portion of the force of the energy-storage spring 3 determined by
25 the left-hand stroke of the clamping piston 14 and by the elastic deformation of the disc brake, while the remaining component of the force of the energy-storage spring 3 still remains closed off within the energy-storage spring 3 by way of the adjusting thread 22 and
30 the female part 23.

This stroke-dependent control of the actuating force can be disturbed by wear of the linings of the disc brake; it is therefore advantageous to integrate a wear adjustment device of conventional construction and
35 method of operation into the clamping piston 14. This is also the case, for other reasons, with the

embodiments of the actuating device that are to be described below, in particular for a rapid rate of response, energy saving or maintaining cleanliness. While in Figure 1 there is shown only the external view of a clamping piston 14 equipped with an integrated wear adjustment device, Figure 2, with its sectional view of the clamping piston 14, shows a possible embodiment of this wear adjustment device 29. It can be seen that the wear adjustment device is of known design and operation described, for example, in the above-mentioned DE 36 19 948 C2, so that further explanations concerning the wear adjustment device are unnecessary.

For the subsequent release of the disc brake the spindle piston 9 is again held in a non-rotatable manner by the stepping motor 20 while the electric motor 26 is actuated and excited in such a way that it rotates the female part 23 by way of the reduction gearing 28 in the direction of screwing on the adjusting thread 22 to the left in relation to the spindle piston 9. Since the axial bearing 24 prevents the female part 23 from moving to the left, the spindle piston 9 is drawn towards the right, re-loading the energy-storage spring 3 to its initial value. The clamping piston 14 follows this movement to the right, under the elastic deformation force of the disc brake to begin with, until the disc brake just rests without force, then under the force of the spring 16.

Instead of the stroke-dependent actuating force control described above, it is possible to provide a force-dependent control means, as with EP 0 334 434 B1 mentioned above. A load cell (not shown) or force sensor which, as with the above-mentioned patent, is integrated in the actuating device for measuring the actuating force exerted in each case, can be used for this purpose. However, the force measuring device can

also be attached to the calliper or calliper frame or can measure the generated braking couple on the calliper mounting. This enables regulation of the actuating or brake tensioning force; for this, the
5 stepping motor 20 must be actuated until the force measuring device indicates that the value to be set for the force has been reached.

In all of the braking and releasing processes for the disc brake, it can be seen that the spindle piston
10 9 and the female part 23 can only be rotated in one direction of rotation by means of the stepping motor 20 or the electric motor 26, that is to say, no reversal of the direction of rotation needs to take place. This permits particularly accurate and rapid regulation of
15 the actuating force in that the stepping motor 20 and the electric motor can both be actuated simultaneously, with short interruptions, if necessary, and/or in a rapidly alternating manner, if necessary at controlled speeds also; by these means, continuous or at least
20 intermediate-valued, rapidly changing, relative rotations in both directions, including the value 0, can be carried out on both screwing parts of the adjusting thread 22, on the spindle piston 9 and on the female part 23. These rotations result in
25 corresponding stroke movements or stroke positions of the clamping piston 14, as described, and thus in corresponding tensioning forces for the disc brake. The regulation of tensioning force is suitable for anti-skid protection, that is, it is rapid and accurate
30 enough to enable the actuating device to co-operate in a functionally reliable manner with an anti-skid control device for the wheels of the rail vehicle.

As a modification, it is possible to provide a simple, electrically operated locking mechanism for the
35 disc body 17, in place of the stepping motor 20; when this is released, the spindle piston 9 rotates under

the torque exerted in the non-self-locking adjusting thread 22 by the energy-storage spring 3. It is also possible to provide a rotationally controllable and/or speed-controllable electric motor in place of the stepping motor 20; here the radial teeth or serrations 18 can cooperate with a pulse counter 30, as shown in Figure 2. In this arrangement, the number of rotations or the angle of rotation of the spindle piston 9 can be accurately controlled by means of the pulse counter 30.

For reasons of safety, the stepping motor 20, the electric motor or the locking mechanism must be constructed so that, in the case of power failure or a similar malfunction, the spindle piston 9 can rotate and the female part 23 can continue to be held in a non-rotatable manner by the worm gearing.

In the embodiment of the actuation device according to Figure 2, a friction brake 31 is provided for the spindle piston 9. To this end, near the outer edge of the piston disc 17, which is again provided with the radial serration 18 for co-operation with the pulse counter 30, the disc 17 carries a radial brake ring surface possibly provided with a brake lining ring 32 against which a brake ram 33 can be pressed under the force of a spring (not shown). The brake ram 33 forms the armature of an electromagnet 34 which is mounted on the housing 2 and which, when actuated, lifts the brake ram 33 from the brake lining ring 32 against its spring loading, so that the spindle piston 9, which is otherwise held in a non-rotatable manner, can be rotated. The excitation of the electromagnet 34 is controlled in such a way, by means of the pulse counter 30, that the spindle piston 9 rotates by angle of rotation required in each case, under the torque created by the energy-storage spring 3 by means of the adjusting thread 22. It is also possible to excite the electromagnet 34 in such a way that the friction brake

31 rubs, so that the speeds required on the adjusting thread 22 for the spindle piston 9 to reach the differential speeds described above can be regulated by this means. The further construction and the operation of the embodiment according to Figure 2 correspond to the embodiment according to Figure 1; a few further reference numbers, which correspond in meaning to Figure 1, are added in Figure 2. The wear adjustment device 29 and the pulse counter 30 have already been explained in connection with Figure 1.

The stepping motor 20 and the electromagnet 34, or the devices used instead of these, are arranged so that they overlap the energy-storage spring 3 in the radially outward direction, resulting in a space-saving, compact arrangement which enables callipers to have replaceable hydraulic power cartridges. It is possible to arrange several stepping motors, electromagnets or devices of correspondingly lower capacity distributed around the circumference of the energy-storage spring in each case; the energy-storage spring itself can also be subdivided into several assemblies of springs distributed around the axis 5, it being possible to arrange the above-mentioned devices between these assemblies of springs if desired. Owing to these designs, actuation devices with a particularly compact shape are possible. Common to all of the embodiments are their simple, cheap construction, their good, rapid controllability and thus their suitability for anti-skid protection, and their reliability owing to the principle of the spring energy store, as well as failure- and error-safety with the use of closed-circuit current principles.

In summary, the electromechanical actuation device has a spindle piston 9 loaded by an energy-storage spring 3, which spindle piston 9 on the one hand is coupled to a clamping piston 14 delivering the

actuating force or the actuating stroke and, on the other hand, is screwed to an axially non-displaceable nut part 23 by means of a non-self-locking adjusting thread 22. The spindle piston 9 can be screwed in the
5 direction of actuation under electrical or other monitoring by means of a stepping motor 20, a locking mechanism 31 or similar, and the nut part can be rotated against the direction of screwing of the spindle piston 9 by an electric motor 26 and a self-
10 locking worm gearing 28. Relative speeds of rotation of the screwed parts can be set up for the adjusting thread 22, enabling rapid and accurate control of the brake actuation.

List of references

- 1 Calliper frame
- 2 Housing
- 5 3 Energy-storage spring
- 4 Wall
- 5 Axis
- 6 Clamping piston
- 7 Tubular section
- 10 8 Axial bearing
- 9 Spindle piston
- 10 Section
- 11 Flange section
- 12 Threaded spindle section
- 15 13 Axial bearing
- 14 Clamping piston
- 15 Clamping ring
- 16 Spring
- 17 Disc body
- 20 18 Radial serration
- 19 Pinion
- 20 Stepping motor
- 21 Shaft
- 22 Adjusting thread
- 25 23 Female part
- 24 Axial bearing
- 25 Worm gear
- 26 Electric motor
- 27 Worm
- 30 28 Reduction gearing
- 29 Wear adjustment device
- 30 Pulse counter
- 31 Friction brake
- 32 Brake lining ring
- 35 33 Brake ram
- 34 Electromagnet

Claims

1. An electromechanical actuation device for a disc brake having a frame (1), including: an energy-storage spring (3) storing an actuating force, a clamping piston (14) which can be axially loaded by this spring for delivering the actuating force, a motor (26) for loading the energy-storage spring (3) via a screw gearing (22) and a braking device (20;31) which monitors the rotation of a rotatable part of the screw gearing in the direction of unloading of the energy-storage spring (3);

in which the screw gearing is formed in a non-self-locking manner as a threaded positioner (22), one part (23) of which is axially supported and can be driven by the motor (26) in the direction of loading of the energy-storage spring (3), and the other part (9), which is coupled axially with the clamping piston (14), can be braked by the braking device, in such a way that the two parts can be set to rotate at different speeds so as to control the actuating force that can be delivered by the clamping piston (14).

2. An actuating device according to claim 1 and having a housing (2), an axially displaceable spindle piston (9) which can be rotated in the housing (2), the spindle piston (9) being axially loadable by the energy-storage spring (3) in the direction of delivery of the actuating force and coupled for rotation by way of an axial bearing (13) to the clamping piston (14), so as to constitute the said other part of the positioner and being screwed to a female part (23) by means of the adjusting thread (22) formed as a trapezoidal thread, which female part (23) can be rotated by the electric motor (26) and is supported against the housing (2) while allowing rotation in the unloading direction of the energy-storage spring (3), the spindle piston being brakable by means of the

braking device.

3. An actuating device according to claim 2, in which the energy-storage spring (3) is supported on the one hand against the housing (2) and on the other hand
5 against a clamping piston (6) which can be displaced axially in the housing (2), and in that the clamping piston (6) is supported against the spindle piston (9) in the direction of unloading of the energy-storage spring (3) by way of an axial bearing (8).

10 4. An actuating device according to claim 3, in which the spindle piston (9) includes an axial tubular section (10) extending radially within the energy-storage spring (3), the end of the tubular section (10) on the clamping piston side carrying a flange section
15 (11) against which, on the storage spring side, there rests the axial bearing (8) for the clamping piston (6), and against which, on the other axial side, there rests the axial bearing (13) for the clamping piston (14), and the other end of the tubular section (10)
20 changing into a threaded spindle section (12) screwed with the female part (23).

5. An actuating device according to any preceding claim, in which the braking device is adapted to be actuated in an electrically controlled manner.

25 6. An actuating device according to claim 5, in which the braking device is an electrically operated locking mechanism, possibly a friction brake (31) which can be released electromagnetically against spring power.

30 7. An actuating device according to claim 5, in which the braking device has a stepping motor (20) or other electric motor controlled for speed or angle of rotation, which motor is coupled by means of radial teeth to the brakable part of the screw gearing having
35 the adjusting thread (22).

8. An actuating device according to claim 4, 5

and 6 or 7, in which the flange section (11) of the spindle piston (9) carries a disc body (17) which in turn carries, at least near its outer edge, a brake lining ring (32) for the friction brake (31) or, as the
5 case may be, radial teeth (18) or a crown gear on its outer periphery for engaging a pinion (19) of the electric motor or stepping motor (20).

9. An actuating device according to claim 8, in which serrations or markings co-operating with a pulse
10 counter (30) are provided on the outer circumference of the disc body (17).

10. An actuating device according to claim 8 or 9, in which the electromagnet (34) of the friction brake (31), and the electric motor or stepping motor (20),
15 are arranged radially outside the energy-storage spring (3), which is formed as a cup-spring assembly, and protrude beyond this spring in the axial direction.

11. An actuating device according to claim 10, in which several such electromagnets and electric motors
20 or stepping motors are arranged distributed around the outer circumference of the energy-storage spring (3).

12. An actuating device according to any preceding claim, in which the clamping piston (14) is loaded by a spring (16) against the direction of actuation.

25 13. An actuating device according to any preceding claim, in which the reduction gearing (28) in the rotary drive of the rotatable part of the screw gearing is formed as a self-locking worm gearing.

14. An actuating device substantially as herein
30 described with reference to Fig. 1 or Fig. 2 of the accompanying drawings.



The Patent Office

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Claims searched: 1-13

Examiner: Peter Squire
Date of search: 25 July 1997

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK CI (Ed.O): F2F FBE FBX F2E EDH EEB ENH

Int CI (Ed.6): F16D 65/16, 30 B60T 13/74

Other: Online:EDOC,WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2141502 A (Westinghouse)	
A	EP 0531643 A2 (Knorr-Bremse)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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